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ABSTRACT

To identify the role of the child's own action in the development of the ability to coordinate perspectives, a spatial localization task was presented to 2 groups of children: 16 children between 18 and 24 months old, and 16 children between 42 and 48 months old. A reward was hidden randomly in one of two identical left-right locations on a turntable as the child watched. Then, either a 180-degree rotation of the turntable by the experimenter or a move by the child to the opposite side of the table reversed the location of the hidden reward with respect to the child. The entire turntable was covered during half of the trials of each type of movement to measure reliance on visual tracking of the correct container. Children received the reward when they correctly identified its hidden location; children's accuracy in locating the reward and a rating of tracking were recorded. Results indicated that some ability to coordinate perspectives mentally is present in children as young as 18 months. Better performance when the child moved as opposed to when the child watched the movement supported the hypothesis that action plays a role in the development of ability. Results also indicated that performance improved with age. (MM)

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# Coordination of Perspective Change in Preschoolers

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Running Head: Preschoolers' Perspective Coordination

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## Abstract

A spatial localization task was presented to 1 1/2- and 3 1/2-year-olds to identify the role of the child's own action in the development of the ability to coordinate perspectives. A reward was hidden randomly in one of two identical left-right locations on a turntable as the child watched. Then, either a 180 degree rotation of the turntable by the experimenter or a move by the child to the opposite side of the table reversed the location of the hidden reward with respect to the child. The entire turntable was covered during half of the trials of each type of movement to measure reliance on visual tracking of the correct container. Correct finds were rewarded. Accuracy and a rating of tracking were recorded.

The results indicated that some ability to coordinate perspectives mentally is present in the child as young as 1 1/2 years of age. Better performance when the child moved as opposed to when the child watched the movement supported the hypothesis that action plays a role in the development of the ability. This was in spite of better tracking ratings during rotation than when the child moved. Tracking generally helped, however. Performance improved with age. Egocentric responses occurred on inactive and/or hidden trials. The findings differ from those in previous studies. Choice of task and controls in the present study offer an explanation for a previous discrepancy in the literature.

# Coordination of Perspective Change in Preschoolers

The purpose of the study was to explore the development of the concept of space in 1 1/2- and 3 1/2- year-olds as manifested in the ability to compensate for changes in view point. The ability, termed the coordination of perspectives by Piaget and Inhelder (1967), has been a source of controversy in the literature with respect to its presence in preschoolers, e.g. Piaget and Inhelder (1967) vs. Shantz and Watson (1970, 1971).

According to Piaget and Inhelder (1967), the coordination of perspectives develops during the concrete operational period and requires the use of projective relations, such as a straight line between two points. They argue that the preschooler, however, is limited to the use of topological relations such as proximity and separation. Within any one perspective, the preschooler locates objects topologically with respect to his/her own right-left body symmetry. The result is an egocentric spatial reference system which produces errors when the child changes position, especially when the child moves around to the opposite side of the stimulus. In this latter case a right-left reversal of the stimulus occurs with respect to the child. Other researchers, e.g., Pufall and Shaw (1973), have replicated this result using rotation of the stimulus array (rotation tasks) instead of movement of the child (perspective tasks).

Results like those of Piaget and Inhelder (1967) and Pufall and Shaw (1973) have been criticized because of the overall level of

difficulty of the tasks they employ. Studies using simpler versions of the task have found that preschoolers are able to coordinate perspectives, (e.g. Shantz & Watson, 1970, 1971). Variables which have been shown to be relevant in simplifying the task are: the number and discreteness of stimuli (e.g., Borke, 1975); the availability of topological information such as colored markers, (Pufall, Note 1), or an outside reference point, (e.g., Huttenlocher & Presson, 1973); the level of difficulty of the required response, (e.g., Borke, 1975; Shantz & Watson, 1970); and the relative size of the space to be dealt with, (e.g., Acredolo, 1977).

Piaget and Inhelder (1967) and Laurendeau and Pinard (1970) suggest that there is a potential hazard in simplifying the task. Preschoolers have at their disposal primitive solutions to spatial problems, the use of which changes the nature of the task. First, they can track the correct hiding place during a change of view. Or, if given an opportunity to see an object during a perspective change, the perceptual memory of that visual sequence can be used as a solution in later trials. In addition, preschoolers can use any topological information that is available to solve what would otherwise be a projective problem in coordinating perspectives. For example, the child could note a hidden object's position with respect to a colored marker, change perspective, and then use the marker to locate the object rather than coordinating the two points of view. The studies which suggest that preschoolers can coordinate perspectives have not always controlled for the use of these

primitive solutions. An effort was made to do so in the present study within the context of a simple task. First, performance was compared with and without opportunity for tracking, and tracking was noted when it occurred. Second, a task with a hidden object was used so that a perceptual memory of a visible sequence would not be available to the child. Third, topological information within the stimulus was eliminated.

In addition to simplifying the task and controlling for alternative solutions, the study attempted to look at the mechanism for the development of the concept of space. Because Piaget and Inhelder (1967) suggested that the child's own activity is a mechanism for the development of the ability to coordinate perspectives, perspective change and rotation tasks were compared. It was hypothesized that performance would be better on perspective change trials where the child was actively involved in the transformation from one perspective to the other than it would be on rotation trials. The age range was lowered to 1 1/2 years because Piaget and Inhelder (1967) suggest that this is the age when a concept begins to develop. It was hypothesized, based on their findings, that the first spatial reference system would be an egocentric one. In addition, it was hypothesized that the availability of tracking would aid performance because it would allow the child to use an easier means of solving the problem.

## Method

### Subjects

The subjects were 32 children from the Amherst, Massachusetts, area. The 16 1 1/2-year-olds were between 18 and 24 months of age, and the 16 3 1/2-year-olds were between 42 and 48 months of age. The average ages in the two groups were 22 and 45 months, respectively. There were equal numbers of males and females in each group. Two younger subjects did not complete the experiment and data were replaced. One refused to cooperate in the initial training procedure; the second was withdrawn by a parent who objected to the reinforcement procedures.

The parents of the 1 1/2-year-olds were located through birth records, informed of the project by letter, and invited to bring their child to the Child Behavior Research Center at the University of Massachusetts, Amherst. These parents accompanied their child during testing and received $3 per visit for travel expenses. Two 3 1/2-year-olds were similarly selected and tested, but others were tested at their respective nursery schools and consequently did not receive any money for participating. The Psychology Department's "Committee on the Use of Human Subjects" approved the procedure in advance.

Stimulus Materials and Procedure

A round plastic turntable 27 cm. in diameter was on a low table in the center of the room. Two identical coasters with removable lids were attached to the turntable surface. They were placed on the

diameter and equidistant from the center in the right-left positions 7 cm. apart. On each trial a reward of dry cereal was hidden under the lid of one of the coasters for the child to find.

Training trials. Training consisted of watching the cereal being hidden and then finding it with no intervening movement to change its position relative to the child. Each child reached a criterion of five consecutive correct responses. All but three children had no training errors. After incorrect choices, the experimenter retrieved the cereal and hid it again. Otherwise, the child was allowed to eat the cereal. To prevent learned bias during training, the order of right or left positions was randomized with the restriction that no more than three of the five correct trials would be on any one side.

Test trials. When the training criterion was met, the experimenter hid the cereal again, and one of two possible movements occurred. On perspective change trials the experimenter pulled the turntable just out of the child's reach so that he/she had to walk around the table to the opposite side to get the cereal. On rotation trials the experimenter rotated the turntable 180 degrees. Both movements produced a right-left reversal of the hidden cereal with respect to the child; consequently, egocentric responses produced errors. Children who made many errors were offered a raisin between every few trials to prevent frustration.

The turntable was either visible or hidden during the movement. On visible trials the child could visually track the correct lid (but not the cereal) during movement. To prevent

tracking on hidden trials, a cake cover was placed over the entire turntable just prior to the movement, and removed upon its completion. To increase the salience of the rotation, the cake cover surface was painted black on one half of the diameter and white on the other. It was always placed so that the black-white border was parallel to the front of the table. For example, the white half would face the child, and after a 180 degree rotation preceded visible rotation, the black half would face the child. Alternatively, when hidden rotation trials preceded visible rotation trials, the child was shown a 180 degree rotation of the uncovered turntable prior to the first trial, to insure that the child knew a movement of the turntable would occur underneath the cover.

Because pilot research suggested that experience with one kind of movement sometimes interfered with performance on the other, all of the trials of one type of movement were completed before the child was exposed to the other type. For perspective change and rotation trials, each child received the same order for the trials of the two visibility conditions (visible and hidden) although order was counterbalanced across children. For example, if a child received visible rotation before hidden rotation, then he or she also received perspective change before hidden perspective change. Two children were randomly assigned to each of the four orders within every age/sex cell.

Each child received 32 trials. For purposes of analysis, the eight trials within each of the four Movement x Visibility conditions were divided into two blocks of four trials each. Within each block,

the right-left position of the hidden object and the direction of movement for the child or the turntable were counterbalanced in a random order. The experimenter controlled the direction the child walked by verbal instruction, pointing, and standing in the way of the incorrect path.

Dependent Variables

Two dependent variables were recorded on each trial: whether or not the response was correct, and a rating from 0 to 5 of the amount of looking at the turntable during movement. To obtain the rating, the 180 degree movement was divided mentally into five parts (arcs of 36 degrees) by the experimenter, and the child was given one point for every part during which he/she was judged to be looking at the turntable. Interobserver agreement on the rating was 96.4%, with no rating differing by more than 1 point and was achieved on the first attempt.

## Results

Absence of any spatial reference system would produce chance responding. An egocentric system would produce a significant number of errors. A decentered system would produce correct responses. To see if performance differed from chance levels in either direction, four two-tailed t-tests were performed on the mean number of correct responses at each age. The results suggested that there is some ability to coordinate perspectives in preschoolers.

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Insert Table 1 about here

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In Table 1 the means are converted to percent correct in each condition. The 3 1/2-year-olds performed better than would be expected by chance on both visible movements, (perspective: $t$ (15)= -7.41, $p$ .05), consistent with the hypothesis that an egocentric spatial reference system was being used.

Table 1 suggests that performance was better in visible over hidden conditions. Two analyses of variance were conducted separately on the correct responses and the attention ratings. A 2 (Age) x 2 (Sex) x 4 (Order) x 2 (Movement) x 2 (Visibility) x 2 (Blocks of Trials) analysis of variance on the sums of the correct responses for the four consecutive trials within each block showed that performance in the visible condition was significantly better than in the hidden one, $F$ (1,16)= 57.30, $p$< .05. Better performance on visible over hidden trials was not due to better attention. The 2 (Age) x 2 (Sex) x 4 (Order) x 2 (Movement) x 2 (Visibility) x 2 (Blocks of Trials) analysis of variance on the sums of the attention ratings within each block of trials showed no differences in ratings on visible and hidden trials.

Table 1 also suggests that there was no effect of type of movement. This was confirmed by the analysis of variance which failed to find a main effect for type of movement. It calls into question the role of the child's own action in the task. The lack of an effect coupled with the better performance on visible trials

implies that tracking could have been the sole means of solving the task. If this were the case, the preschoolers would have been choosing the perceptual solution of tracking, rather than coordinating perspectives. But other findings suggested that, although tracking may have been an aid, it was not solely responsible for better than chance performance.

First, there was a significant Movement x Visibility interaction. When the turntable was visible, 70% of both perspective and rotation trials were correct. But when the turntable was hidden 47% of responses were correct when the child walked around, compared to only 36% when the turntable was rotated, $F$ (1,16)= 9.39, $p<.05$. Second, the analysis of variance of attention ratings showed a significant difference between the ratings for the two types of movements, $F$ (1,16)= 19.88, $p<.05$. Attention ratings during rotation averaged only 88%, but during perspective movement they averaged only 65%, yet performance during visible perspective change was no different than that during rotation. This was not due to a lack of correlation between ratings and correct responses on visible trials. Spearman correlation coefficients were obtained for the children's attention ratings and number correct in the four perspective and rotation conditions separately. Higher attention ratings were associated with correct responses during visible perspective movement, ($r$= +.43), and visible rotation, ($r$= +.71). Both correlations were significant, $p<.05$, N=32, but did not differ from each other. There was no relation between attention rating and

response during hidden movement (perspective: $r$= +.09, N=32; rotation: $r$= +.13, N=32).

In general, practice improved performance, with the percentage of correct responses increasing from 52% to 60%, $F$ (1,16)= 8.51, $p$<.05. But this trend did not hold for all conditions separately. The percentage coorect increased from 45% to 61 % during rotation trials, but remained at 59% during the child's perspective movements. This interaction was significant, $F$ (1,16)= 7.41, $p$<.05. It suggests that an initial difference between movement conditions may have been obscured by practice effects. Practice effects during visible and hidden trials were also different. There was no improvement during visible trials where the percentage correct increased from 34% to 49%. The difference in effects of practice with and without a cover was significant, $F$ (1,16)= 4.76, $p$<.05. This suggests that some improvement occurred despite unavailability of tracking.

Trial 1 responses and attention ratings were examined to look at responses before practice effects occurred. The responses of both age groups were analyzed with the sign test to determine if the number of correct trial 1 responses in hidden and visible perspective change and hidden and visible rotation was greater or less than would be expected by chance. The number of children at each age who were correct on the first trial of each condition is reported in Table 2 along with the average percentage of rated attention on that trial.

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Insert Table 2 about here

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It can be seen that the 3 1/2-year-olds performed above the chance level of eight correct on the first visible perspective change trial, $x^2$ (1, .05)=7.56. The 1 1/2-year-olds performed at chance levels on the first trial of hidden rotation as well as visible rotation. Performance on the first trial of hidden rotation was significantly below chance levels fro the 1 1/2-year-olds; all 16 children were incorrect, $x^2$ (1, .05)=14.06. But the trend for attention ratings went in the opposite direction. Attention ratings were highest where children performed the worst, namely, in hidden rotation. These findings suggest that the child's own action aided performance, with less dependence on visual tracking on active trials.

Performance improved with age; the overall percentages correct were 66% and 46% for the 3 1/2- and 1 1/2-year-olds, respectively, $\underline{F}$ (1,16)= 30.96, $\underline{p}$<.05. The 3 1/2-year-olds also averaged significantly higher attention ratings than the 1 1/2-year-olds. The percentages of rated looking time for the two age levels were 82% and 71%, respectively, $\underline{F}$ (1,16)= 4.67, $\underline{p}$<.05. Neither age tended to choose the hiding place which was most proximal to them during the movement; however, the 1 1/2-year-olds did tend to choose the hiding place on the right ($x^2$ (1, .05)= 4.54). There were no sex or order effects.

## Discussion

The findings suggested that some ability to coordinate perspectives may be present in the 3 1/2- and 1 1/2-year-old within the context of a simplified version of Piaget and Inhelder's (1967) original task. Controls ruled out the possibility that the primitive mechanism of tracking was solely responsible for correct responses, although tracking probably aided the child in the task. Visual perceptual memory and topological relations within the stimulus were not available to the child as easier alternative solutions. Topological relations with respect to the room, (e.g., the door), were available to the child. However, the evidence did not support the conclusion that the child used these relations to solve the task. Use of an outside cue such as the door would have produced correct responses during perspective trials and incorrect responses during rotation trials. This pattern was not found. Furthermore, none of the children were observed to glance back and forth between any location in the room and one of the lids. Such comparisons might be expected if the child were using an external referent.

Although the lack of a significant main effect for type of movement suggested that the child's own action was not important in the task, a closer look at the data did support this interpretation. The difference between movements was obscured by practice effects. Performance improved in the conditions where it was initially low, namely, rotation and hidden trials. Anecdotal information from the study may indicate what it was that the

children were learning through practice. On rotation and hidden trials children would often miss the first trial or two, and then would begin to be correct. But each time they were correct they would express their delight and amazement at the magical fact that the cereal was in the "wrong" place. They learned to be correct without understanding what was going on. Other children expressed the same thing nonverbally by beginning to reach egocentrically, but then stopping short and forcing (with what appeared to be great effort) their arm over to the "wrong" place.

One important unanswered question concerns the poor performance during hidden perspective change. If the child's own action gave some measure of independence from tracking to the child, then why wasn't this reflected in the performance on hidden perspective change? One potential explanation lies in the nature of spatial knowledge. Siegel and White (1975) suggest that knowledge about space is constructed by and consists of visual recognition memory. It is possible that placing the cover over the turntable interfered with the child's visual recognition memory of the turntable. As a result, the child was unable to transform the relations in memory in concordance with his of her movement around the table.

The greater egocentric responding of 1 1/2-year-olds supported Piaget and Inhelder's (1967) original finding of an early egocentric spatial reference system. The egocentric responding of both age groups on hidden and rotation tasks is consistent with Pufall's (1975) suggestion that egocentrism is characteristic of a

wide range of ages, and depends on the task. Perhaps the egocentric spatial reference system is retained throughout the life span for use in stationary tasks.

One incident suggested that egocentric and decentered spatial reference systems coexist in the child. The first trial for one 3 1/2-year-old was a visible perspective change. The cereal was hidden on the boy's right and he was told to walk around the right side of the table. When he reached the opposite side, he looked at and bent toward the correct hiding place which was now on his left. But his right arm suddenly shot out toward the egocentric hiding place on his right. He looked in surprise at his right arm, then regained control and chose the correct hiding place on his left.

In summary, contrary to Piaget and Inhelder (1967), these results supported the existence of the ability to coordinate perspectives in preschoolers. The importance of the child's own action in the development of spatial cognition was supported. An early egocentric reference system was found.

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Table 1

Percentages of Correct Responses of 3 1/2- and 1 1/2-Year Olds in Each Movement and Visibility Condition

| | Perspective | | Rotation | |
|---|---|---|---|---|
| Age | Visible | Hidden | Visible | Hidden |
| 3 1/2 | 78 | 57 | 79 | 48 |
| 1 1/2 | 62 | 36 | 60 | 23 |

Table 2

Number of Correct Responses and Percentage of Rated Attention on the First Trial of Each Condition

| | Perspective | | Rotation | |
|---|---|---|---|---|
| Age | Visible | Hidden | Visible | Hidden |
| | Number of Correct Responses [a] | | | |
| 3 1/2 | 15 | 7 | 11 | 2 |
| 1 1/2 | 10 | 6 | 6 | 0 |
| | Percentage of Rated Attention | | | |
| 3 1/2 | 71 | 80 | 95 | 99 |
| 1 1/2 | 60 | 54 | 82 | 94 |

[a]Maximum number possible= 16